Hands-On Relay School 2013

Teleprotection Schemes and Equipment

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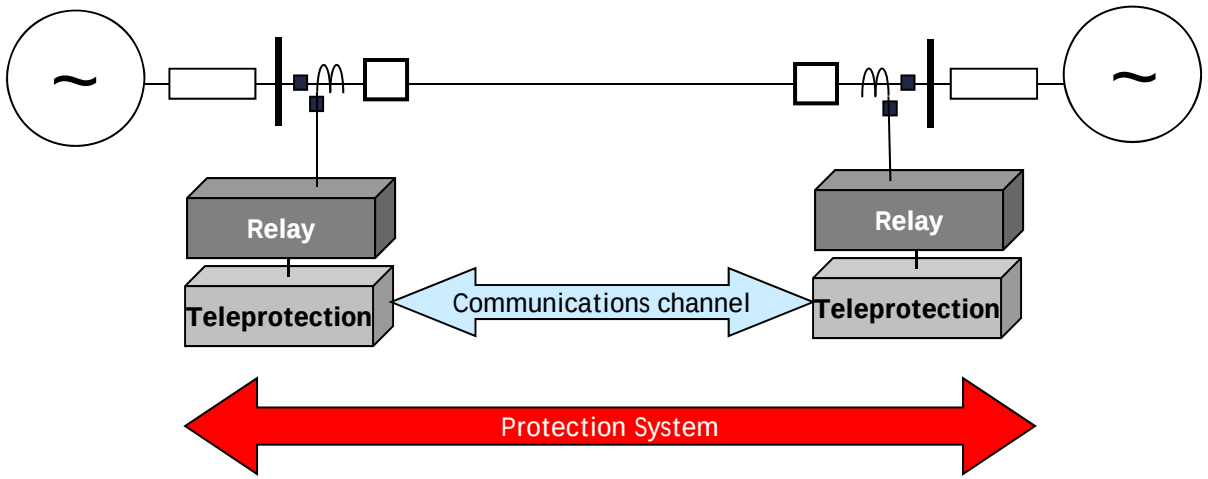
Teleprotection Schemes And Equipment



Why Use Communications?

Teleprotection provides several important benefits

- **Trip only the faulted line section.**
- **High speed simultaneous clearing for all internal line faults including end zone faults.**
- **Prevents overtripping on external line faults.**
- **Allows existing lines to transmit greater power.**
- **Reduces transmission line damage.**
- **Allows for high speed reclosing.**

Teleprotection History

- AC Pilot Wire Relays
  - Short lines
- Directional Comparison with Distance Elements
  - Power Line Carrier
  - Analog Microwave
  - Audiotone
- Phase Comparison*
  - Power Line Carrier
- Current Differential and Charge Comparison*
  - Audiotone
  - Digital Channels

Relaying Communication Equipment

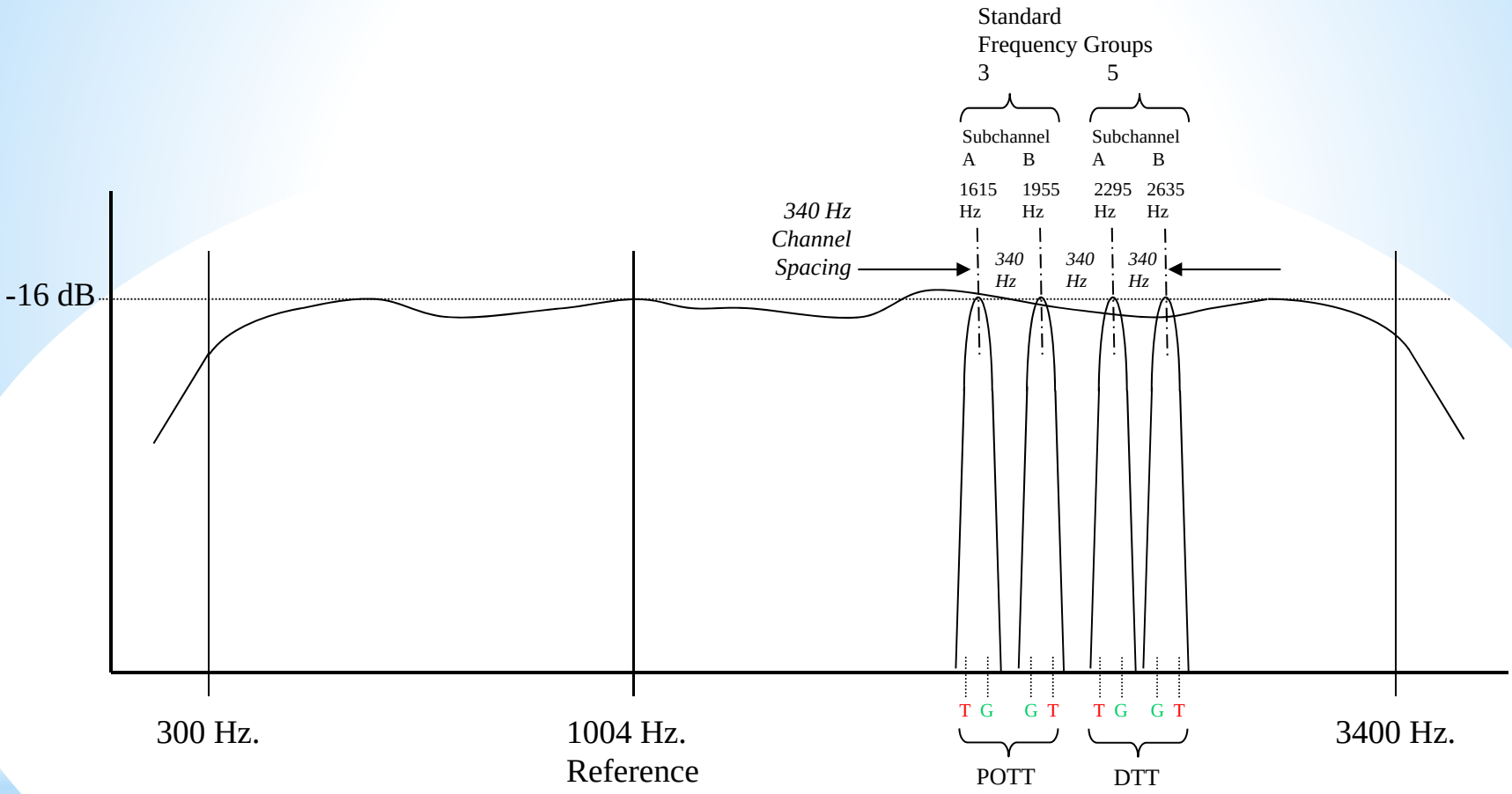
- **Analog Channels** → FSK Tones
  - Analog Microwave channels
  - Leased Telephone Lines
  - Multiplexer voice channels
- **Digital Channels** → Proprietary and Industry standard codes
  - Digital Microwave channels
  - Leased Digital Data Service
  - Multiplexer data channels
- **Dedicated Fiber Optic Cable**
  - Singlemode Fiber
  - Multimode Fiber
- **Powerline Carrier** → RF Frequency coupled to Transmission line.
  - On / Off Carrier
  - Frequency Shift Carrier

- Pilot Wire
  - Metallic cable between the substations
- Voice Channels, Audiotone
  - Leased telephone lines
  - Analog microwave
- Digital media
  - CSU/DSU 2,400 bps to 56/64 kbps leased phone line
  - Dedicated fiber optic pair (C37.94)
  - Multiplexed digital networks (T1/SONET/MPLS)
    - Communication link may be fiber, metallic or digital microwave
  - Spread Spectrum Radio
    - Very limited use for protection signaling

Coming soon to a substation near you….
Packetized data Ethernet/IP Teleprotection

IEC 61850

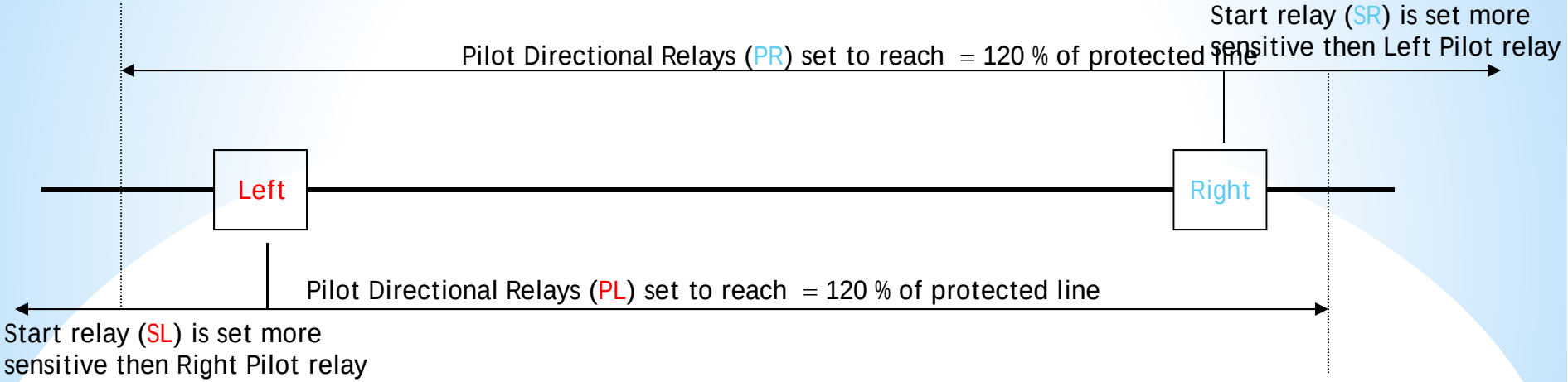
Analog Voice Channel Frequency Allocation

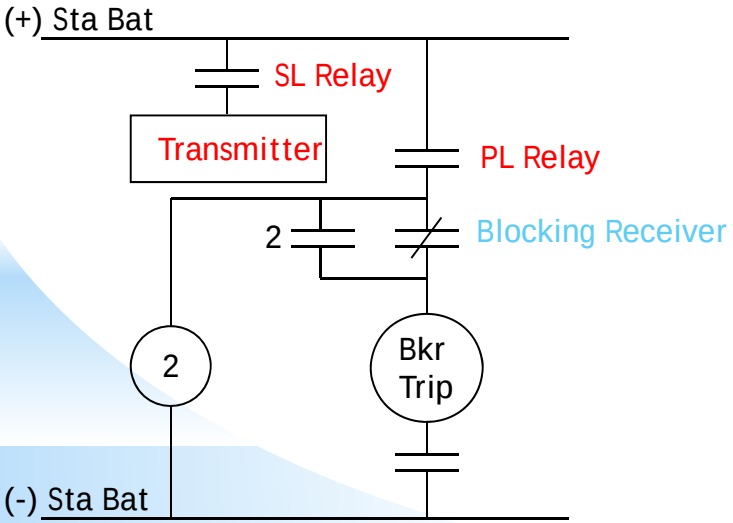


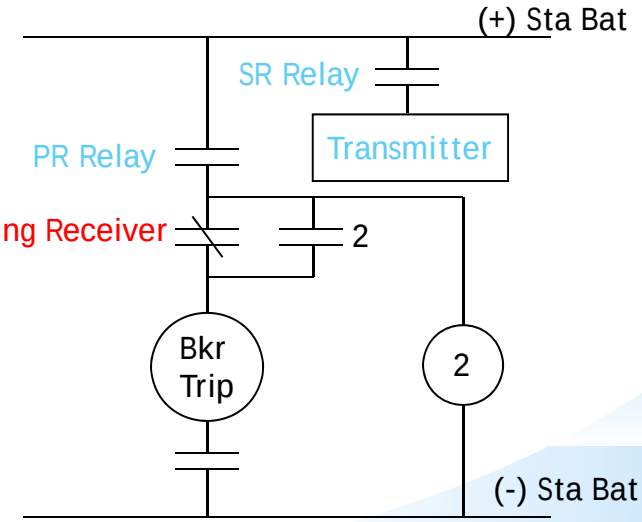
Frequency Group 3
(+/- 75 Hz. Shift)
Trip A = 1540 Hz.
Guard A = 1690 Hz.
Guard B = 1880 Hz.
Trip B = 2030 Hz.

Frequency Group 5
(+/- 75 Hz. Shift)
Trip A = 2220 Hz.
Guard A = 2370 Hz.
Guard B = 2560 Hz.
Trip B = 2710 Hz.

Directional Comparison Blocking







Blocking channel requirements

Operate Time:
Blocking applications require channels times between 3 to 5 msec. These times are necessary to prevent the remote terminal from “Over Tripping” on external faults.

Security:
Blocking applications require minimal security because the communication channel can not cause a false trip

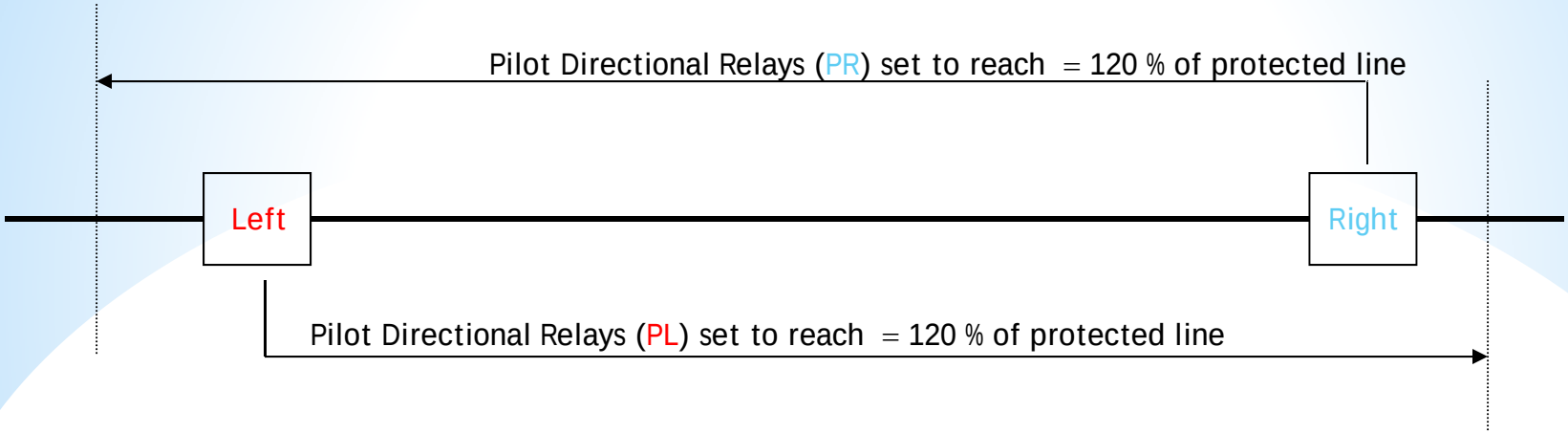
Dependability:
Blocking applications are highly dependably because the relaying system will operate without the teleprotection channel.

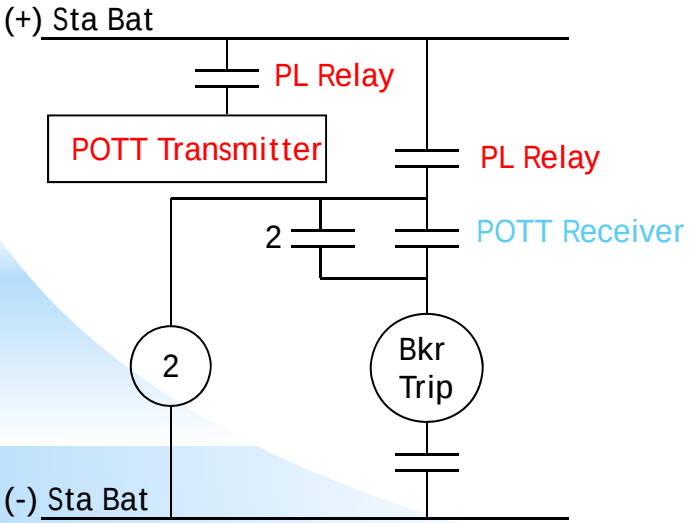
Analog Channel:
Rarely used because of the slow operate times. Channels require wide bandwidth for fast operate times. Power utility may have to lease telephone channels.

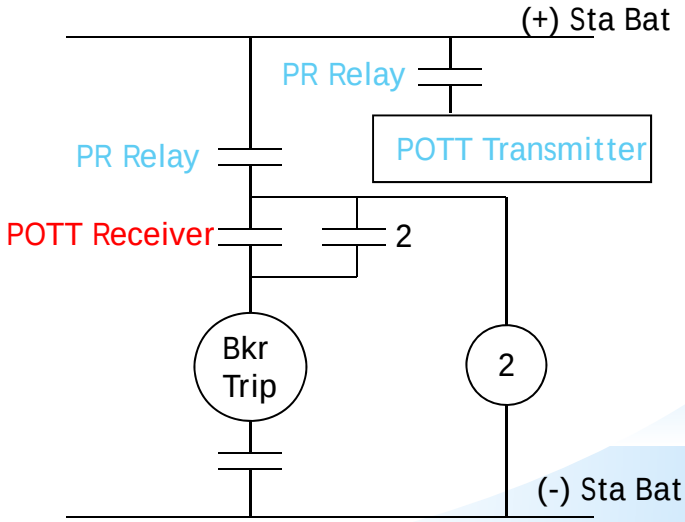
Digital & Fiber Optic:
Becoming more popular because of the fast operate times, and increasing availability.

Powerline Carrier:
Most popular because of a large installed base. The power utility has complete control over the communications channel, and the equipment.

Permissive Transfer Tripping







Permissive channel requirements

Operate Time:
Blocking applications require channels times between 8 to 12msc. These times are necessary to allow the remote terminal to trip quickly for all internal line faults

Security:
Permissive applications require security to prevent the channel from enabling a trip. Typical problems occur for current reversals on parallel lines.

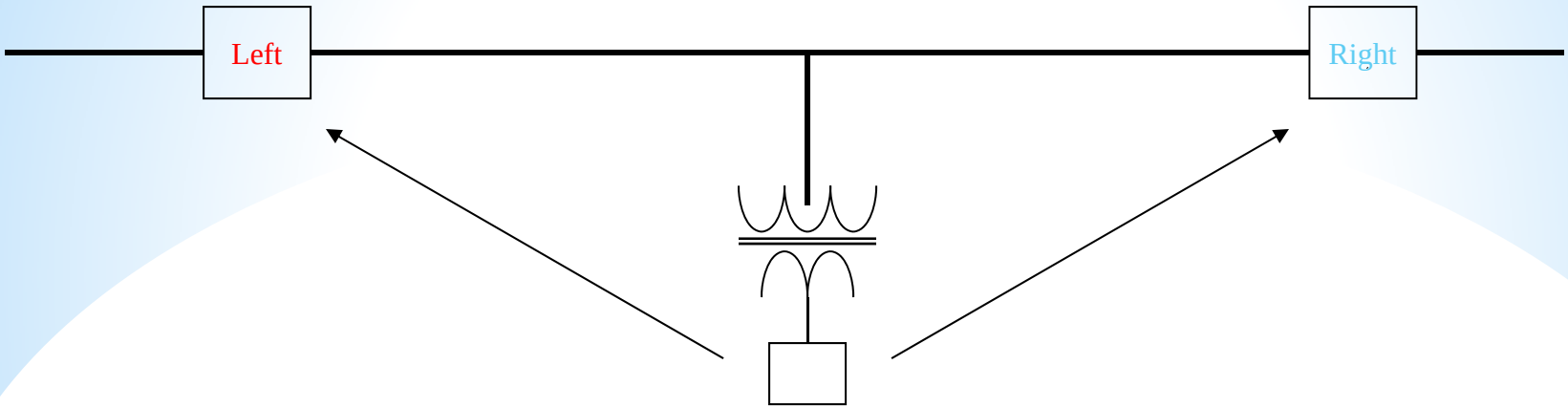
Dependability:
Permissive applications require dependably to permit high speed clearing of both terminal. Unblock trip outputs are commonly used to enable tripping should the channel fail, coincident with a line fault.

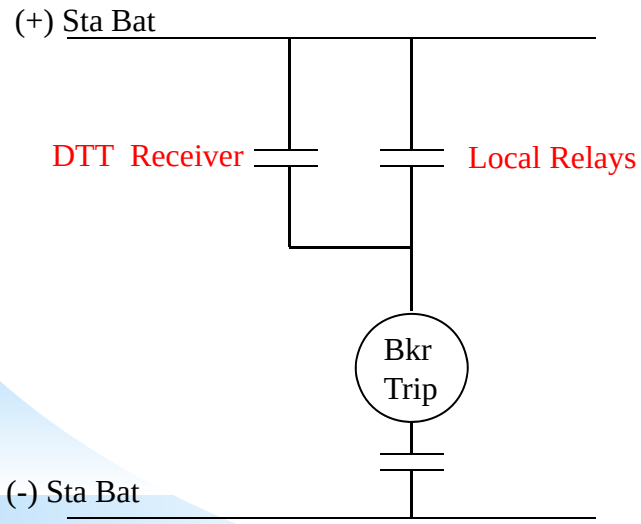
Analog Channel:
Commonly used because they offer diverse routing. Channels require medium bandwidth to provide the required operate times.

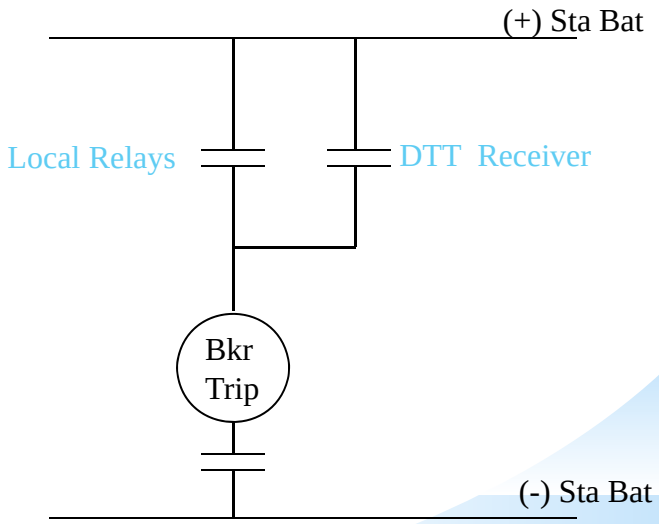
Digital & Fiber Optic:
Becoming more popular because of the fast operate times, and increasing availability.

Powerline Carrier:
Most popular because of a large installed base. The power utility has complete control over the communications channel, and the equipment. Unblock trip output is always provided, either programmed into the relay, or the communication equipment.

Direct Transfer Tripping







Direct Transfer Trip channel requirements

Operate Time:
DTT applications require typical channels times around 12msc. These times are not as critical as Blocking, or Permissive applications, as these are backup functions.

Security:
DTT applications require very high security to prevent the channel from directly causing a false trip output.

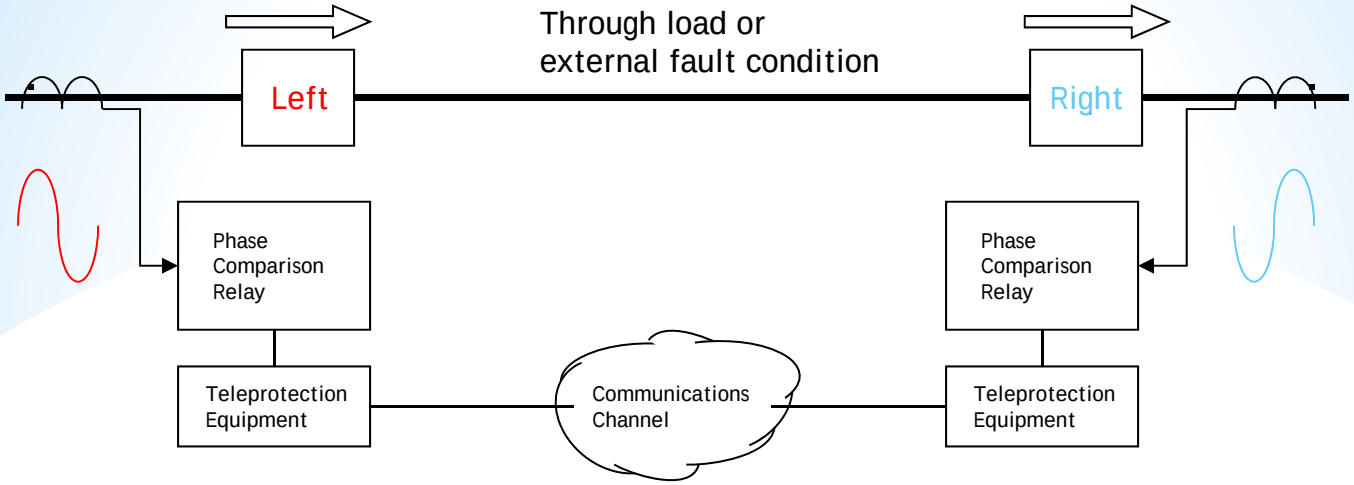
Dependability:
DTT applications require very high dependably. This application is typically a breaker failure backup, and must operate to limit equipment damage.

Analog Channel:
Commonly used because they offer reliability due to diverse routing. Channels require medium bandwidth to provide the required operate times. Applications always use dual tones, on a dedicated channel, to provide high security.

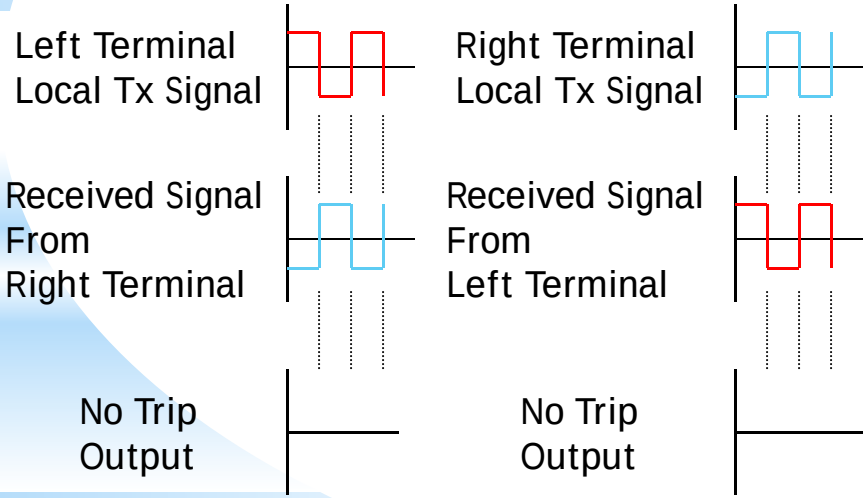
Digital & Fiber Optic:
Becoming more popular because of the fast operate times, high security, dependability and increasing availability.

Powerline Carrier:
Most popular because of a large installed base. The power utility has complete control over the communications channel, and the equipment. Unblock trip output is never used in DTT applications.

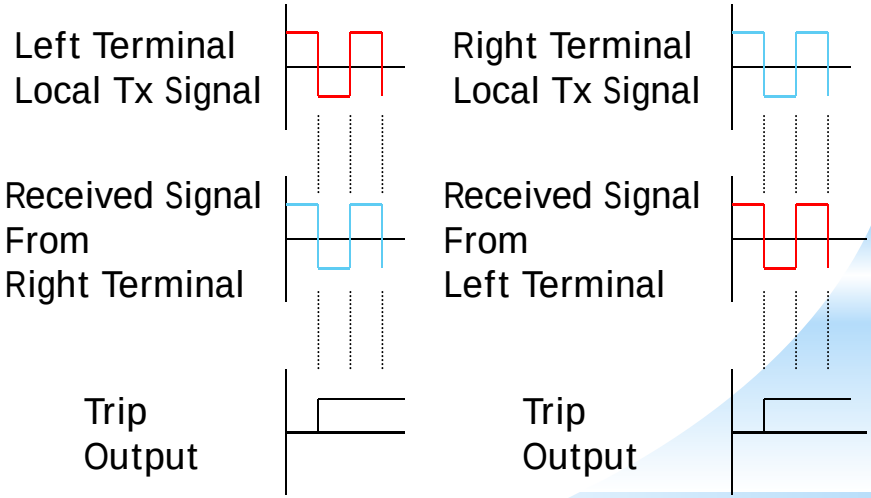
Phase Comparison Relaying



External Fault Conditions



Internal Fault Conditions



Phase Comparison Relay Channel

Operate Time:
Phase Comparison applications require channels times around 8 ms. The channel delay should be constant, as excessive channel delay time will cause a phase shift in the composite current signal.

Security:
Single Phase Comparison applications utilize a “Blocking” philosophy, and can over trip on loss of signal. Dual phase comparison system utilize frequency shift keying, and an Unblock Trip” philosophy. This system utilizes an 150 ms unblock trip output to permit tripping upon loss of channel

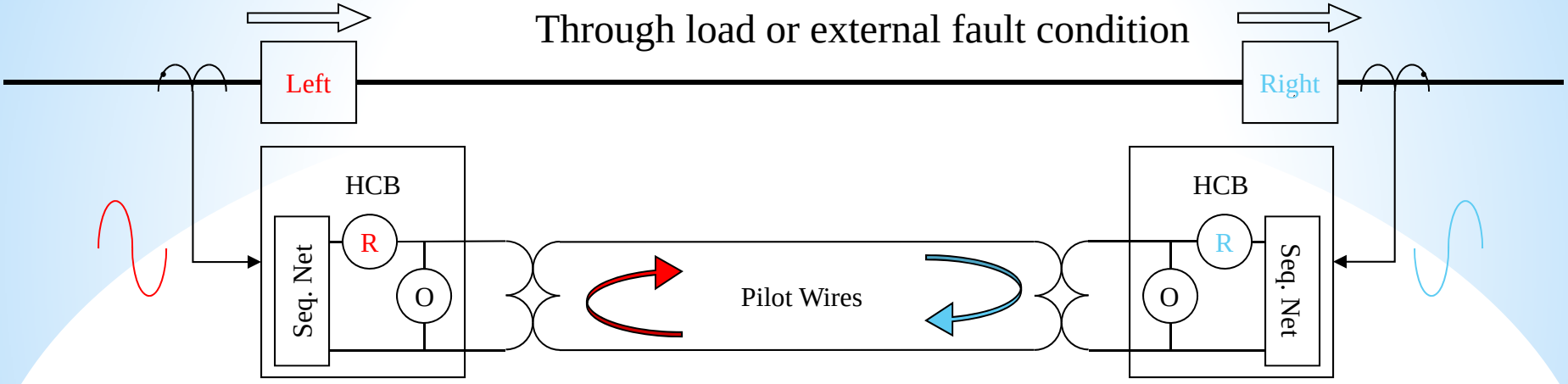
Dependability:
The single phase comparison system is more dependable because receipt of a tripping command is not required to trip the system.

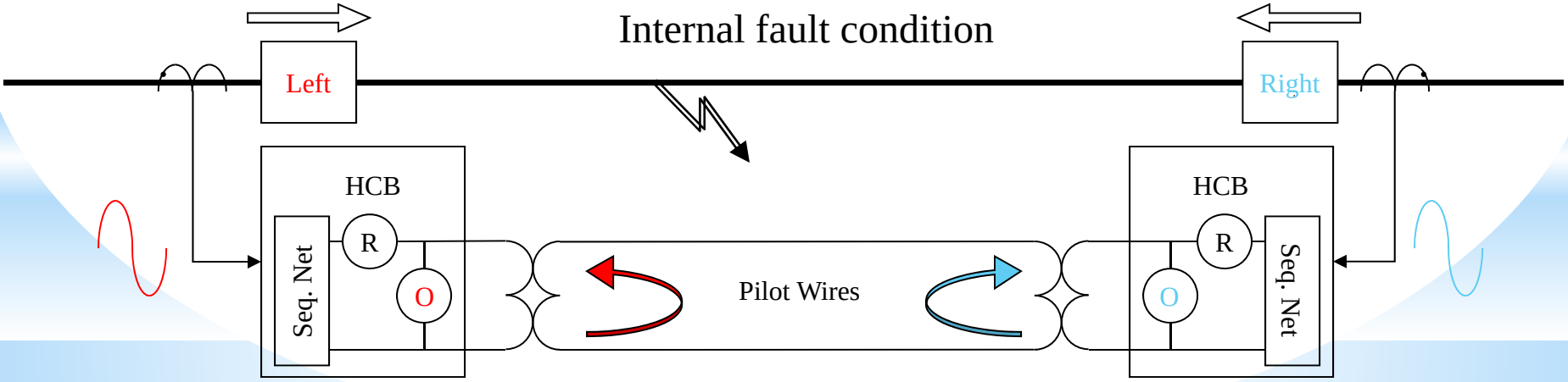
Analog Channel:
Frequency shift audio tones are commonly used for this application.

Digital & Fiber Optic:
Becoming more popular because of the fast channel times, and increasing availability. Channel delay could be critical if the teleprotection is applied on a switched network.

Powerline Carrier:
On/Off Powerline carrier is used for single phase comparison systems, while FSK carrier is used for dual phase comparison systems.

Current Differential Protection





Current Differential channel requirements

Operate Time:
Current differential applications require channels times less then 1 msec. Excess channel delay time will cause a phase shift in the composite current signal.

Security:
Because of the large amount of data required for current differential applications, a loss of channel is more probable then a false trip. False tripping would most likely occur if the HCB operated as a over current relay, or on the independent transfer trip function.

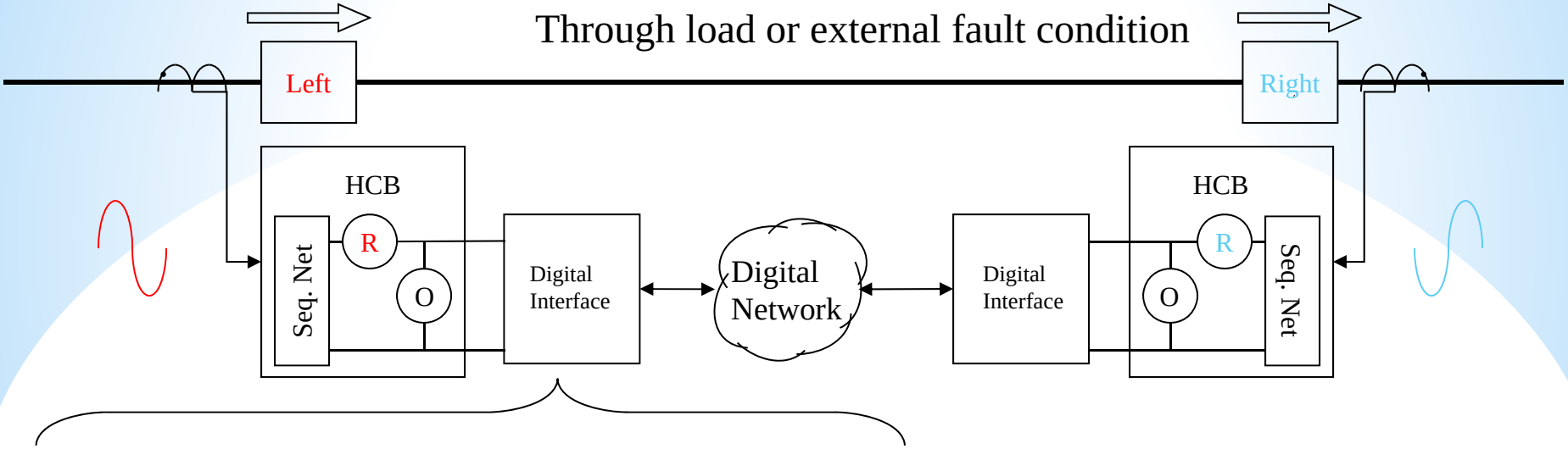
Dependability:
Dependability is critical for current differential applications, because without communications the relay system will not operate.

Analog Channel:
Not recommended for current differential applications, because of the excessive channel delay times.

Digital & Fiber Optic:
Becoming more popular because of the fast channel times, and increasing availability. Channel delay is critical and must be calculated for each channel routing.

Powerline Carrier:
Powerline carrier is never used for current differential applications because the channel may be corrupted and unavailable when the line is faulted.

Effects of channel delay on Current Differential Protection



0° Phase Shift
No Channel Delay

Left Terminal Local Signal

Right Terminal Received Signal

Differential Current

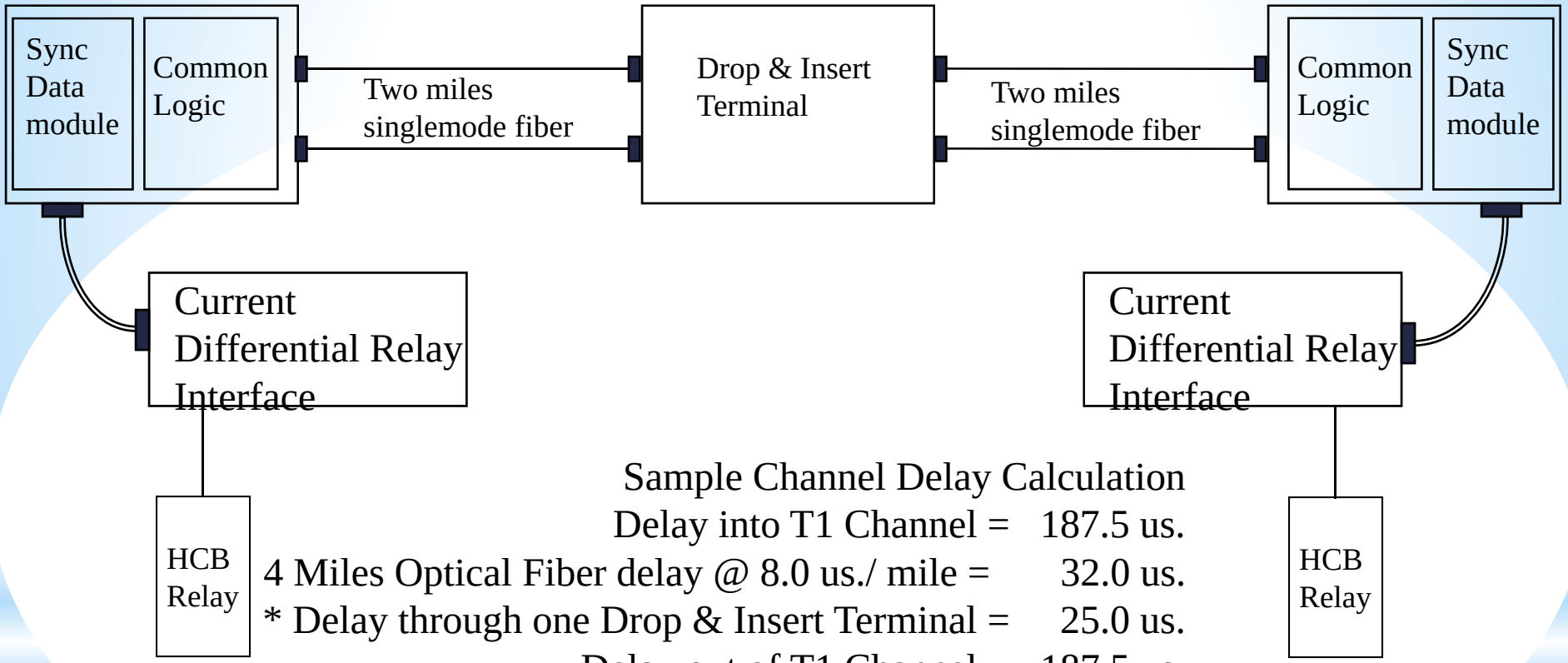
90° Phase Shift
4 msec Channel Delay

Left Terminal Local Signal

Right Terminal Received Signal

Differential Current

Channel Delay Time over T1 Multiplexer



Sample Channel Delay Calculation

Delay into T1 Channel =	187.5 us.
4 Miles Optical Fiber delay @ 8.0 us./ mile =	32.0 us.
* Delay through one Drop & Insert Terminal =	25.0 us.
Delay out of T1 Channel =	187.5 us.
Total delay time =	432.0 us.

* Note:
Systems utilizing Digital Access and Cross-connect (DACS) units will incur a 250us delay going into and out of each DACS.

Iniven

Relay I/Os

Relay I/Os

Powerline Carrier

Transmission Line Communications Medium

Advantages:

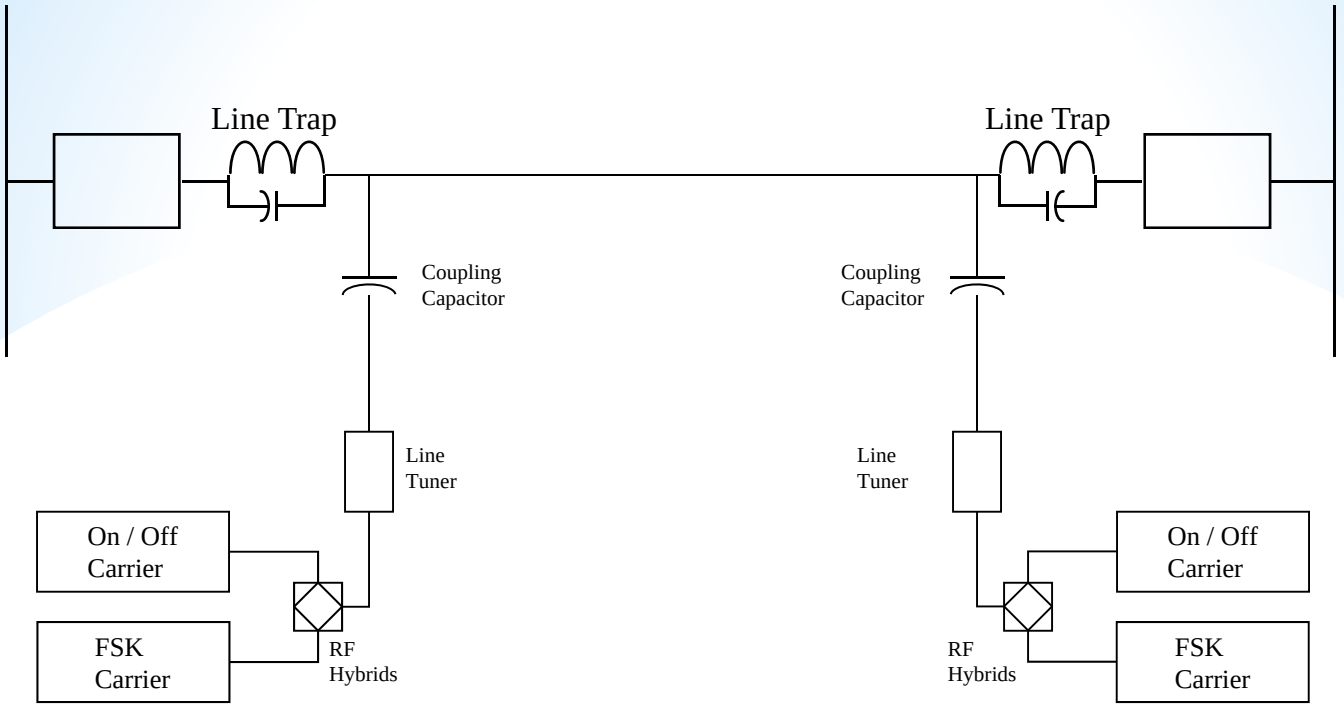
1. The powerline offers a robust medium that is designed for reliable service.
2. The powerline is under the complete control of the utility.
3. The powerline originates, and terminates at the desired locations.

Disadvantages:

1. Increased signal attenuation may occur at the time of the fault.
2. Noise levels may increase at the time of the fault.

The powerline carrier signal must be coupled to the transmission line with expensive line tuning equipment.

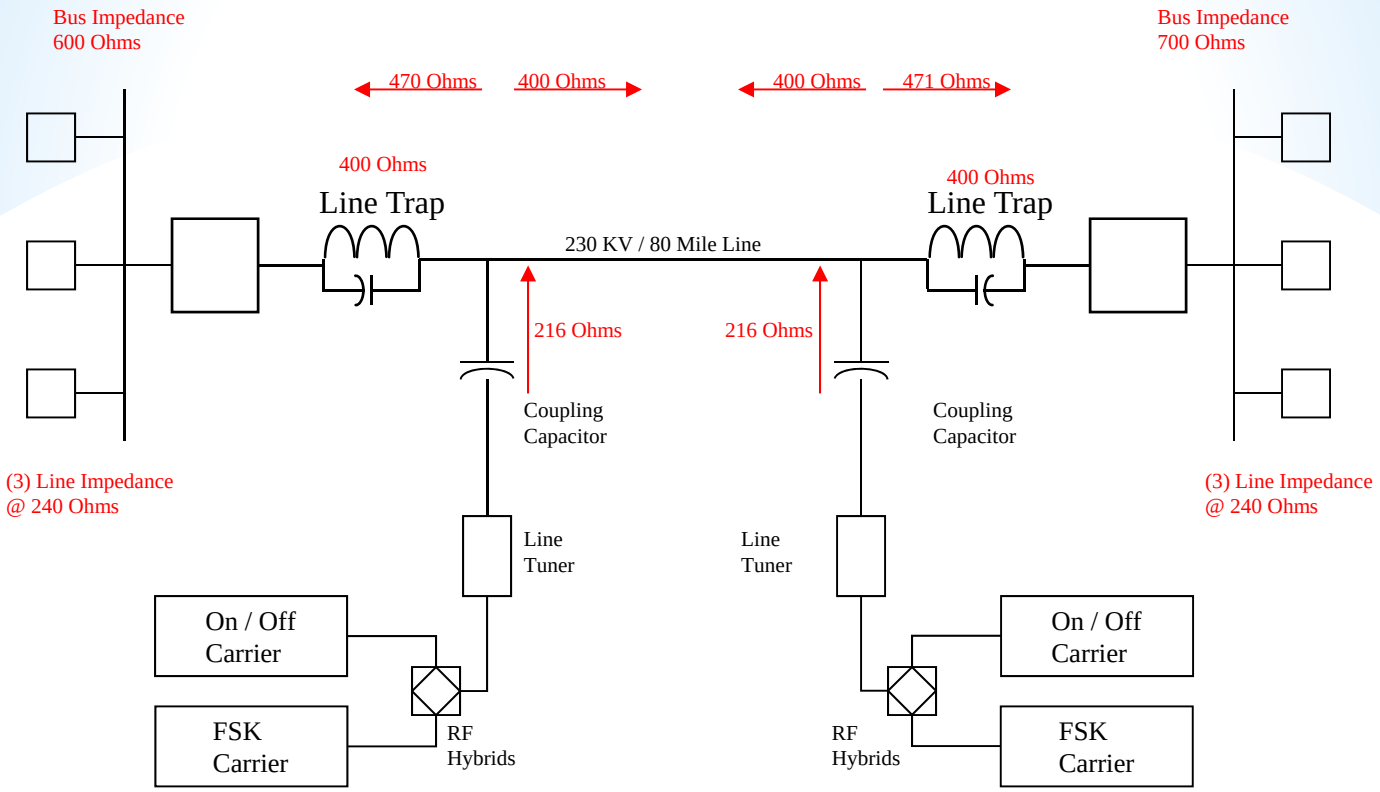
Typical two terminal line, powerline carrier system



Powerline Carrier System Components

- Transmission Line
- Line Tuners
- Coupling Capacitors
- Line Traps
- RF Hybrids
- PLC Transmitter, and Receiving equipment
- Interconnecting coaxial cables

Typical two terminal line, powerline carrier system



References and Credits:

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